

## On the life cycle of *Sepia officinalis* (Cephalopoda, Sepioidea) in the ria de Vigo (NW Spain)

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**Abstract :** From 1 325 specimens of *S. officinalis*, 612 males and 713 females, caught in 572 trawl hauls from April 1982 to February 1987 in the ria de Vigo, it is inferred that this species lives and spawns throughout the ria, including the inner part where there are large fluctuations in salinity (20-35.5 ‰). It is distributed preferentially along the shores of the central and outer basins of the ria. The highest frequency of apparition occurs in autumn. The main spawning season covers spring and summer, but winter spawning was also observed. Females larger than 120 mm ML were more abundant than males of these size. Males are more precocious than females. Mature and immature animals of both sexes were found in the population the year round.

**Résumé :** A partir de 1 325 spécimens (612 mâles et 713 femelles) de *Sepia officinalis* capturés dans la ria de Vigo en 572 chalutages entre avril 1982 et février 1987, les auteurs concluent que cette espèce vit et pond dans toute la ria et pénètre aussi dans la partie interne de la ria où elle supporte d'importantes fluctuations de la salinité (20-35 ‰). Cette espèce se répartit de préférence dans la périphérie des bassins central et externe de la ria. Sa présence est plus élevée pendant l'automne. Les plus grandes femelles (LDM  $\geq$  120 mm) sont plus abondantes que les mâles presque pendant toute l'année. Les mâles sont plus précoces que les femelles. Durant toute l'année, il y a des mâles et des femelles matures et immatures dans la population. La plus importante période de ponte s'étend de février jusqu'à la fin de l'été, mais l'espèce pond dans la ria pendant toute l'année.

### INTRODUCTION

*Sepia officinalis* Linnaeus, 1758, is one of the best known Cephalopods. It is a demersal and neritic species, occurring from the coastline to about 200 m. depth, predominantly on sandy and muddy bottoms. Its tolerance to salinity variations is relatively high. Its life span is about 2 years reaching a maximum 30 cm ML. The highest growth rates are of about 0.6 to 0.9 mm increase in ML per day at 20 °C, but they vary directly with temperatures. Seasonal offshore-inshore migrations have been observed. Spawning occurs throughout the year in shallow waters, although the main spawning season covers spring and summer between 12-15 °C. The size of maturation is very variable. Males are more precocious than females (Mangold-Wirz, 1963 ; Richard, 1971). Boletzky (1983) has reviewed the principal literature on this species.

The aim of this work is to provide some data on the life-cycle of *S. officinalis* in the ria de Vigo, an estuarine system, and to compare them with those found in other areas of the Old World.

### MATERIAL AND METHODS

The area studied is a drowned tectonic valley of 176 km<sup>2</sup>. It was divided into 8 zones (Fig. 1). The criteria used to make these divisions were hydrographic : nature

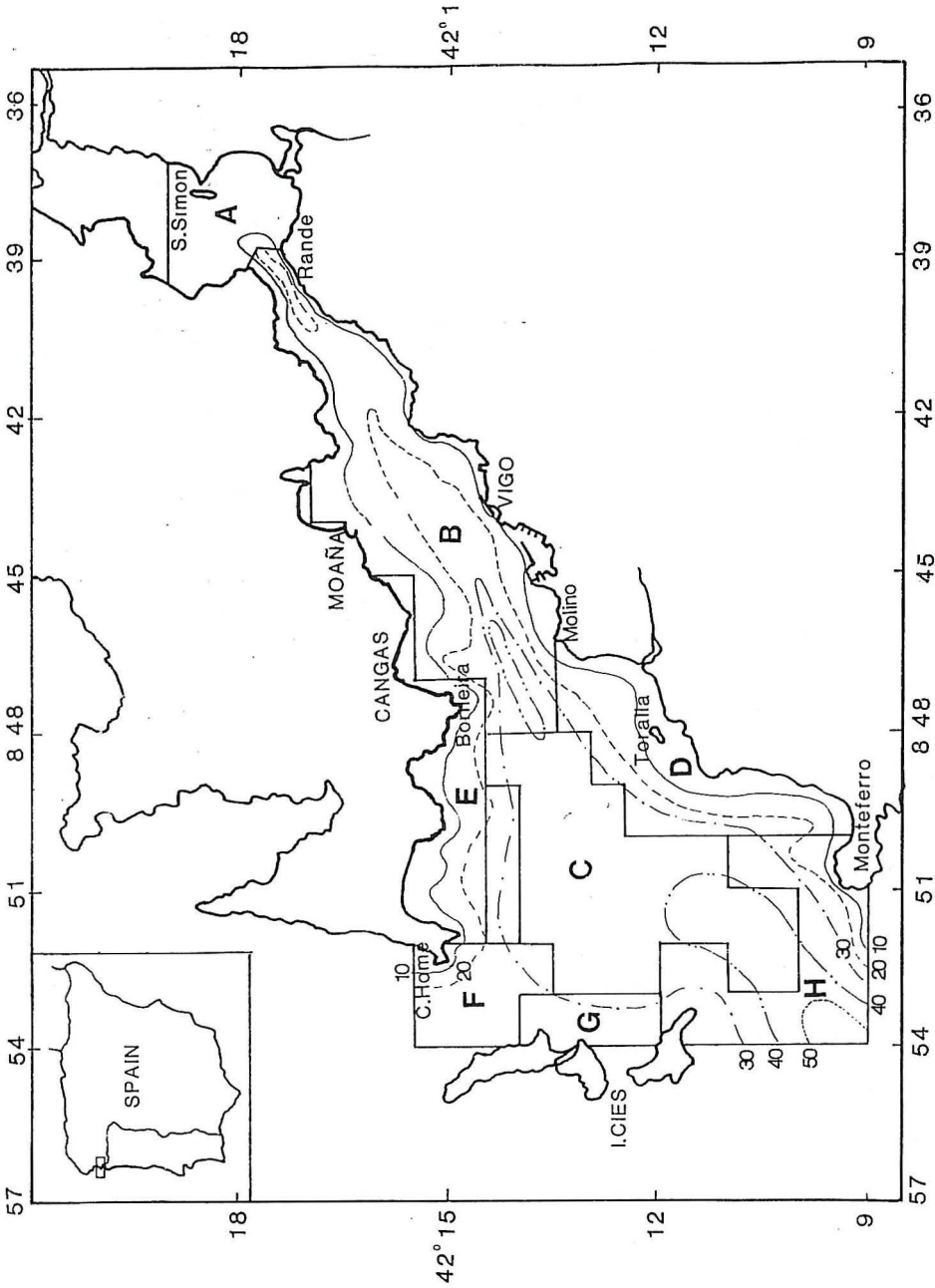


Fig 1 - Map of the ria de Vigo. The eighth zones in which it was divided are shown. The isobars are in m.

of the bottoms, bottom profile and depth. These zones are as follow :

- Zone A - The San Simon inlet, with important salinity and temperature fluctuations, absent elsewhere. Depth range 2-22 m. Bottom muddy and heavily covered by algae, *Zostera marina*, and sponges.
- Zone B - The central basin. Depth range 2-45 m. Muddy bottom plenty of shell fragments, rocky in some zones. Algae very abundant.
- Zone C - External basin. 30 to 45 m depth. Muddy bottom without algae.
- Zone D - Southern coastal zone. Rocky and shell sand covered by algae bottom. 0-30 m depth.
- Zone E - Northern coastal zone. Bottom similar to zone D 0-23 m depth.
- Zone F - The northern mouth of the ria. Rocky bottom. Depth range 0-45 m.
- Zone G - Cies Islands area. Rocky and shell sand bottom in the middle, muddy in the deepest zone (30 m) and sandy near the cost. Algae abundant.
- Zone H - Southern mouth of the ria. Rocky and shell sand bottom, covered by algae in some places. Depth range 0-60 m.

A total of 1 325 specimens, 612 males and 713 females, were studied. These specimens were caught in 572 trawl hauls. The sampling period spread from April 1982 to February 1987. The gear used in 539 hauls was a small bottom trawl with 30 mm cod-end mesh size. The weight of each trawl board of the gear was 15 kg. The rest of hauls were made with a beach seine. The sampling methodology and the methods employed on board ship to process the catches are given in Alonso-Allende and Guerra (1984), Guerra (1984), and Guerra *et al.*, (1986).

The dorsal mantle length (ML) in mm., total body weight (WT) in g., sex and maturation stages were determined in all specimens. The stages of maturation were determined according to the similar scale shown in Mangold-Wirz (1963) and Alonso-Allende and Guerra (1984).

Seasons were defined as follow :

I. Winter = January - March. II. Spring = April - June.

III. Summer = July - September. IV. Autumn = October - December.

## RESULTS

Table 1 shows the relative abundance and presence of *S. officinalis* in each of the 8 zones explored. A significant ( $p \leq 0.001$ ) heterogeneity of presence - absence records in all the zones was found. Table 2 shows the significance levels obtained by comparing the zones among themselves by means of a Chi square test. Both tables show the existence of a higher appearance frequency in zones B, A, D than in zone E, with intermediate value, and C and H of the lowest appearance frequency (Table 2). Zones F and G were not compared because of the low number of haul made in them.

TABLE 1 - Relative abundance and presence of *S. officinalis* in the 8 explored zones of the ria de Vigo.

| ZONE | Nb TRAWLS* | Nb SPECIMENS | PRESENCE IN TRAWLS<br>% |
|------|------------|--------------|-------------------------|
| A    | 54         | 89           | 68.5                    |
| B    | 220        | 907          | 81.4                    |
| C    | 62         | 27           | 17.7                    |
| D    | 71         | 179          | 64.8                    |
| E    | 4          | 83           | 49.0                    |
| F    | 11         | 2            | 18.2                    |
| G    | 13         | 25           | 61.5                    |
| H    | 29         | 13           | 24.1                    |

\*Hauls outside the zones were not taken on account.

TABLE 2 - Significance levels the Chi square test obtained by comparing the presence-absence of *S. officinalis* in the different zones.

| ZONES | B   | C   | D   | E   | H   |
|-------|-----|-----|-----|-----|-----|
| A     | n.s | *** | n.s | n.s | *** |
| B     |     | *** | **  | *** | *** |
| C     |     |     | *** | *** | n.s |
| D     |     |     |     | n.s | *** |
| E     |     |     |     |     | n.s |

xxx =  $p \leq 0.001$  ; xx =  $p \leq 0.01$  ; x =  $p \leq 0.05$  ; ns = not significant.

The average depth where *S. officinalis* was caught was  $11.43 \pm 10.14$  m in the zone A, and  $16.82 \pm 5.83$  in the rest of the ria.

From the above data, the conclusion is drawn that this species lives throughout the ria de Vigo, including the inner area (S. Simon inlet) where the influence of the fresh water is the greastest ; there are large fluctuations in bottom salinity (20-35.5 %) and temperature (11-22 °C) (Anadon *et al.*, 1961 ; Prego, per. comm.). In the central and external basins of the ria, whose maximum depth is 45 m, *S. officinalis* is distributed preferentially inshore, on different bottom types.

Table 3 provides the relative abundance and presence seasonal in trawis of this species. A significantly ( $p \leq 0.05$ ) heterogenous presence in all seasons was observed Between seasons only differences was observed among spring-autumn ( $p \leq 0.01$ ) and summer-autumn ( $p \leq 0.01$ ), being autumn the season with the grea-test-presence.

Figure 2 shows the length (ML) frequency distributions of all specimens examined, per sex and seasons. The mean (x) and standard deviation (s) of each distri-



bution are shown. It was impossible to make a growth analysis using the Petersen method. The largest males observed were of 205 mm ML, and the largest females measured 235 mm ML.

The relationship between ML in mm and fresh total body weight (W) in g is expressed by the equations:

$$W = 0.00054 \text{ ML}^{2.6908} \quad (r = 0.9940) \text{ for males. Fig. 2 (a).}$$

$$W = 0.00053 \text{ ML}^{2.6978} \quad (r = 0.9912) \text{ for females. Fig. 2 (b).}$$

Table 4 shows the proportion of sexes observed in each season for different size classes and the total of specimens. Significance levels of a Chi square test are also shown. These results indicate that females ML  $\geq 120$  mm were more abundant than males all year round except in autumn. Females were also more abundant than males in the first season, and in the whole sample.

The percentage of specimens in each maturation stage (Table 5) shows that males are more precocious than females; mature males of 60 mm ML were observed, while the first mature females measured 80 mm ML. Sexual maturity may be attained at very different sizes.

From observations on maturation stages in each season (Fig. 3), the conclusions can be drawn that there are immature and mature males and females throughout the year, although winter and spring are the main maturation periods.

During sampling, 34 spawns were caught from February to August. The spawning places were the whole zone A, and the banks of zones B, D and F. Depth ranged from 1 to 24 m.

According to maturation and spawning data, the main spawning season of this species in the ria de Vigo covers spring and summer, but winter spawning has also been observed. Spawning occurs at temperatures between 11 and 22 °C and salinities ranging from 20 to 35.5 ‰.

The newly hatched animals obtained in the laboratory measured  $8.4 \pm 0.62$  mm ML (N=17).

## DISCUSSION

Life in inshore waters exposes *S. officinalis* to hydrologically unstable conditions (Richard, 1971; Boletzky, 1983). The species is known to live and spawn in the inner part of the ria, where salinity ranges from 20 to 35.5 ‰. Boletzky (1983) has pointed out that this species can survive for some time at salinities around 18 ‰ if slowly acclimatized, and that it is relatively tolerant to salinity variations. On the contrary, *Sepia elegans* does not enter in the inner part of the ria (Guerra & Castro, in press). Hendrix *et al.*, (1981) have shown that *Lolliguncula brevis* is an euryhaline and osmoconforming species able to live in estuaries at Galveston Bay. With the above observations on *S. officinalis*, we suggest that this species may be also considered as euryhaline.

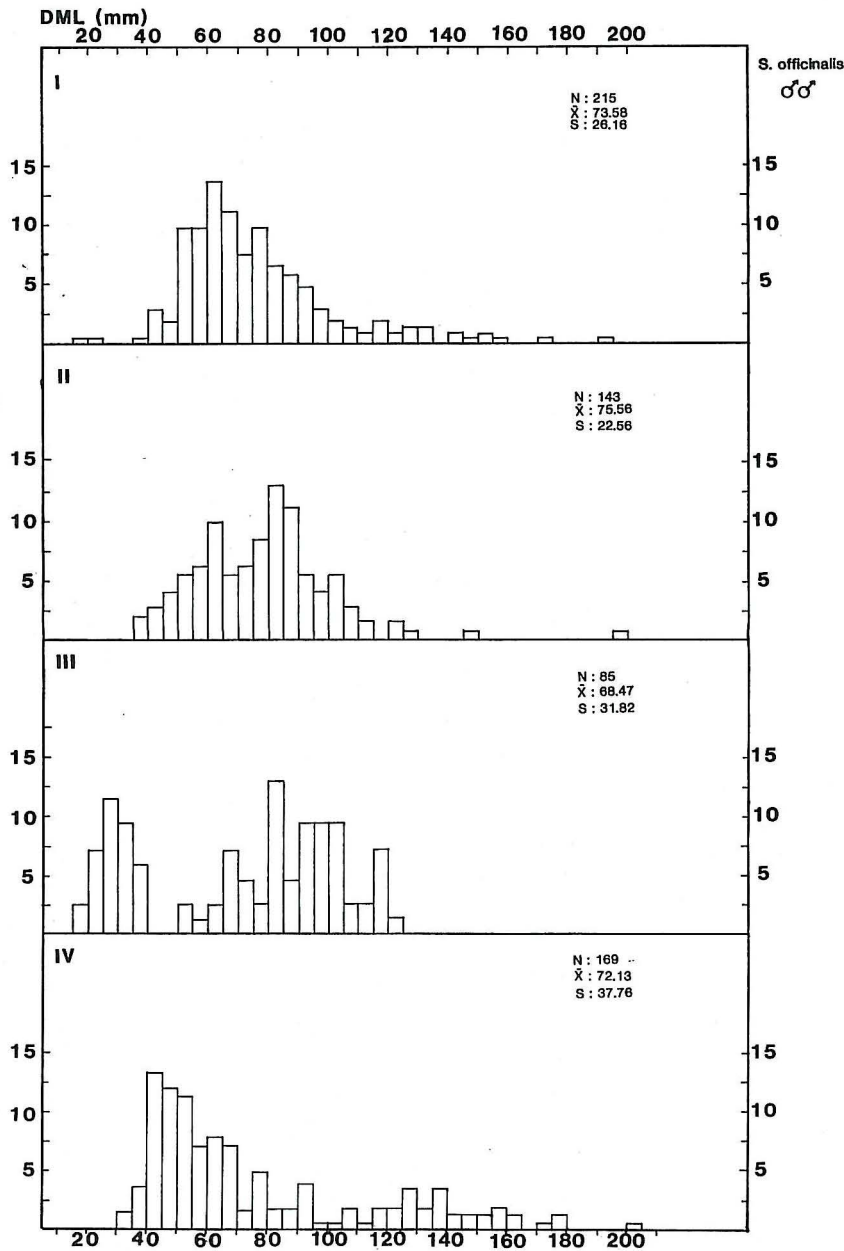


Fig. 2 (a) - Lenght (ML) frequency distributions of males *S. officinalis*.  
I-IV: seasons quarters.

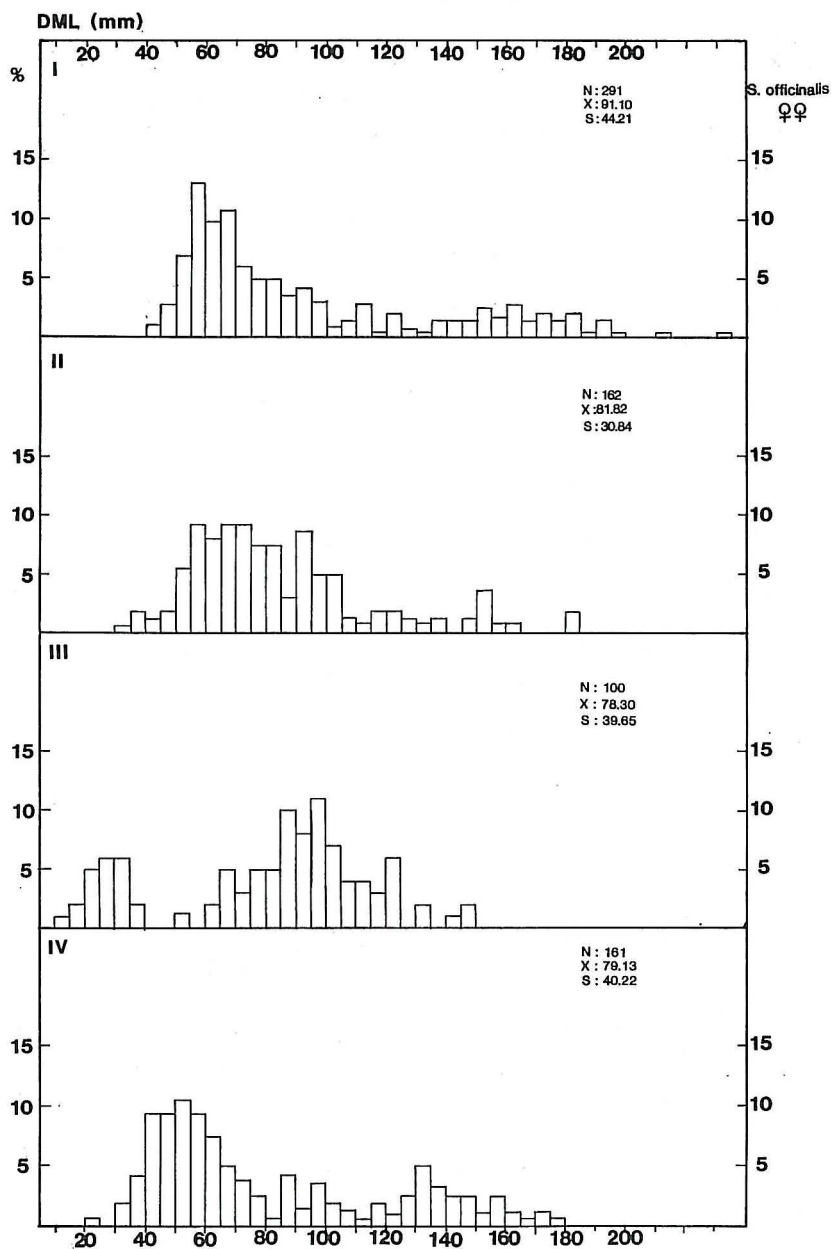


Fig 2 (b) - Length (ML) frequency distributions of females *S. officinalis*  
I-IV : seasons quarters.

The general *S. officinalis* maturation pattern in the ria coincides with that observed by Mangold-Wirz (1963) in Western Mediterranean Sea. This author also noted that this species may attain sexual maturity at different sizes. The males being more precocious than females. The minimum size of fully mature males coincides with our observations (60 mm). In females we have found fully mature specimens of 80 mm ML. Richard (1971), under laboratory conditions, has also observed that males are more precocious than females at same age.

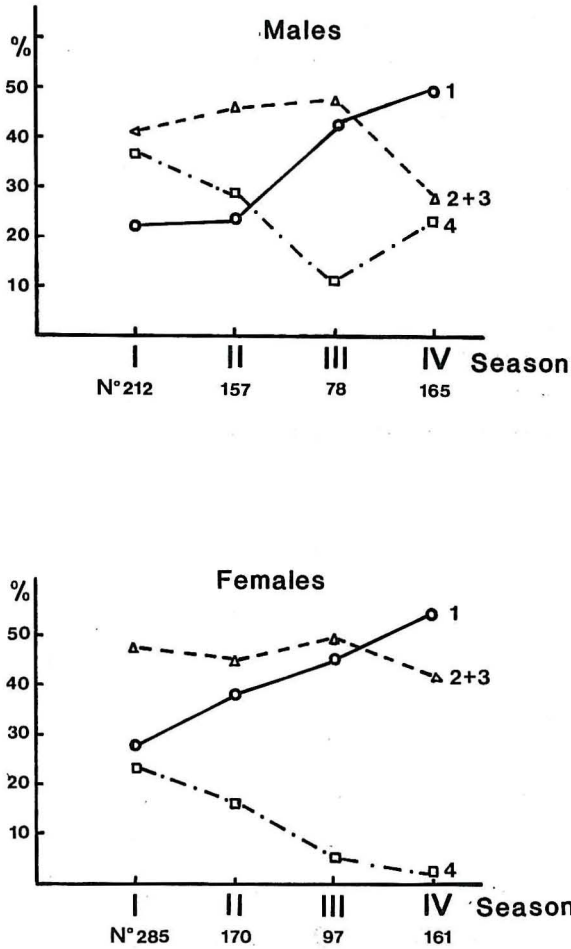


Fig 3 - Percentages of males and females of *S. officinalis* from the ria de Vigo, in each maturation stage for each season. 1 : immatures ; 4 : matures.



Spawning takes place in the ria inshore waters, mainly in the inner area (S. Simon inlet), where a commercial fishery has been developed using traps and gill-nets, which covers the main spawning season. Possibly seasonal migrations between shallow and deeper waters occur in the ria.

Spawning season of this species in Western Mediterranean sea covers spring and summer, but winter spawning has also been observed (Mangold-Wirz, 1963). In the Channel area and the North Sea, this species seems to spawn only in spring and summer (Richard, 1971; Mattacola *et al.*, 1984). In the ria de Vigo, the spawning season is more closely related to that observed in the Mediterranean than to that reported in the North Atlantic, because winter spawns take place. This could be due to milder winter conditions in the ria than on the Atlantic coasts of Europe. In a more temperate area of the Atlantic, along the Senegalese coast, Bakhayokho (1983) has found that the spawning season of *S. officinalis hierredda* covers February to September.

TABLE 3 - Relative seasonal abundance and presence of *S. officinalis* in the ria de Vigo

| SEASON | Nb TRAWLS (NT) | Nb SPECIMENS (NS) | PRESENCE IN TRAWLS<br>% |
|--------|----------------|-------------------|-------------------------|
| Winter | 141            | 506               | 51.1                    |
| Spring | 184            | 304               | 46.2                    |
| Summer | 136            | 185               | 44.9                    |
| Autumn | 111            | 330               | 64.0                    |

TABLE 4 - Size (mm) and sex proportions of *S. officinalis* in the ria de Vigo at different seasons of the year.

| SEASON | SIZE    |  | SEX  |    | SIZE          |  | SEX  |     | SIZE     |  | SEX  |    | TOTAL |     |
|--------|---------|--|------|----|---------------|--|------|-----|----------|--|------|----|-------|-----|
|        | ML ≤ 65 |  | M    | F  | 65 ≥ ML ≤ 120 |  | M    | F   | ML ≥ 120 |  | M    | F  | M     | F   |
| Winter |         |  | 85   | 94 |               |  | 114  | 122 |          |  | 16   | 72 | 215   | 291 |
|        |         |  | n.s. |    |               |  | n.s. |     |          |  | ***  |    | ***   |     |
| Spring |         |  | 44   | 46 |               |  | 94   | 95  |          |  | 5    | 20 | 143   | 161 |
|        |         |  | n.s. |    |               |  | n.s. |     |          |  | **   |    | n.s.  |     |
| Summer |         |  | 31   | 25 |               |  | 53   | 65  |          |  | 1    | 10 | 85    | 100 |
|        |         |  | n.s. |    |               |  | n.s. |     |          |  | **   |    | n.s.  |     |
| Autumn |         |  | 97   | 83 |               |  | 43   | 39  |          |  | 29   | 39 | 169   | 161 |
|        |         |  | n.s. |    |               |  | n.s. |     |          |  | n.s. |    | n.s.  |     |
| Total  |         |  |      |    |               |  |      |     |          |  |      |    | 612   | 713 |
|        |         |  |      |    |               |  |      |     |          |  |      |    | **    |     |

\*\*\* =  $p \leq 0.0001$ ; \*\* =  $p \leq 0.01$ ; \* =  $p \leq 0.05$ ; n.s. = not significant.

A surprising result found is the disproportion between males and females ML >120. This could be due to several reasons : different growth rates, greater female than male survival, or male migration at this size. Richard (1971), Pascual (1978) and Boletzky (1983) found that males grow more and have longer life-span than females. Whether the same thing occurs in nature, only large males migrations offshore remain as explanation. However, this result might be due to an insufficient sampling.

The difficulty of defining year classes in Cephalopods has been exposed by many authors (see Boyle, 1983). *S. officinalis* does not make an exception. From the length frequency distribution obtained, is was impossible by Battacharya method to define any cohort. The low specimen number used may be one of the reason. Furthermore, it exists a continuous recruitment and significant differences in the growth due to changes of temperature during the life-span of the species, Richard (1971) has observed very strong changes in growth between 13 and 15 °C, very frequent temperatures in the ria de Vigo.

TABLE 5 - Percentage of *S. officinalis* each maturation stage for each sex and size.

| SIZE CLASSES<br>ML (mm) | MALE MATURATION STAGE % |       |       |        |     | FEMALES MATURATION STAGES(%) |       |       |        |     |
|-------------------------|-------------------------|-------|-------|--------|-----|------------------------------|-------|-------|--------|-----|
|                         | 1                       | 2     | 3     | 4      | Nb  | 1                            | 2     | 3     | 4      | Nb  |
| 10                      |                         |       |       |        | -   | 100.00                       |       |       |        | 1   |
| 20                      | 100.00                  |       |       |        | 8   | 100.00                       |       |       |        | 11  |
| 30                      | 100.00                  |       |       |        | 20  | 100.00                       |       |       |        | 14  |
| 40                      | 76.00                   | 22.00 | 2.00  |        | 50  | 96.55                        | 3.45  |       |        | 29  |
| 50                      | 58.23                   | 36.70 | 5.07  |        | 79  | 85.33                        | 14.67 |       |        | 75  |
| 60                      | 44.66                   | 36.89 | 7.77  | 10.68  | 103 | 62.50                        | 37.50 |       |        | 120 |
| 70                      | 27.50                   | 36.25 | 13.75 | 22.50  | 80  | 46.67                        | 50.00 | 3.33  |        | 90  |
| 80                      | 13.10                   | 29.76 | 16.67 | 40.48  | 84  | 32.86                        | 58.57 | 7.14  | 1.43   | 70  |
| 90                      | 25.00                   | 23.44 | 21.88 | 29.69  | 64  | 37.68                        | 43.48 | 11.59 | 7.25   | 69  |
| 100                     | 2.56                    | 25.64 | 25.64 | 46.15  | 39  | 20.37                        | 50.00 | 24.07 | 5.56   | 54  |
| 110                     | 5.56                    | 22.22 | 16.67 | 55.56  | 18  | 4.76                         | 47.62 | 38.10 | 9.52   | 21  |
| 120                     |                         | 14.29 | 9.54  | 76.19  | 21  | 10.71                        | 35.71 | 25.00 | 28.57  | 28  |
| 130                     |                         |       | 6.66  | 93.34  | 15  | 4.76                         | 38.10 | 28.57 | 28.57  | 21  |
| 140                     |                         |       |       | 100.00 | 8   |                              | 30.00 | 10.00 | 60.00  | 20  |
| 150                     |                         |       |       | 100.00 | 10  |                              | 15.38 | 19.23 | 65.38  | 26  |
| 160                     |                         |       |       | 100.00 | 7   | 4.55                         | 4.55  | 13.64 | 77.27  | 22  |
| 170                     |                         |       |       | 100.00 | 1   |                              | 7.69  | 23.08 | 69.23  | 13  |
| 180                     |                         |       |       | 100.00 | 1   |                              | 6.67  | 6.67  | 86.67  | 15  |
| 190                     |                         |       |       | 100.00 | 1   |                              |       |       | 100.00 | 6   |
| 200                     |                         |       |       | 100.00 | 2   |                              |       |       | 100.00 | 5   |
| 210                     |                         |       |       |        | -   |                              |       |       | 100.00 | 1   |
| 220                     |                         |       |       | 100.00 | 1   |                              |       |       | 100.00 | 1   |
| 230                     |                         |       |       |        | -   |                              |       |       |        | -   |
| 240                     |                         |       |       |        | -   |                              |       |       | 100.00 | -   |
|                         |                         |       |       |        | 612 |                              |       |       |        | 713 |

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**Resumen** : A partir de 1 325 ejemplares de *S. officinalis* (612 machos y 713 hembras) capturados en la ría de Vigo en 572 arrastres, entre Abril de 1982 y Febrero de 1987, se concluye que esta especie vive y pone en toda la ría penetrando en la parte más interna (ensenada de S. Simón) donde soporta importantes fluctuaciones de salinidad (20-35.5 ‰). La especie vive preferentemente en la márgenes de la cuencas central y externa de la ría. El otoño es la época en que es más frecuente. Las hembras de mayor tamaño (LDM  $\geq$  120 mm) son más abundantes que los machos casi durante todo el año. Los machos son más precoces que las hembras, y durante todo el año hay machos y hembras inmaduros y maduros en la población. El período más importante de puesta abarca desde Febrero hasta finales del verano, aunque la especie pone en la ría durante todo el año.

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